many unprofitable controversies. General theories of evolution are not to be established on speciation, either by natural selection, isolation or mutation.

Gravitation furnishes what might be called a background for hydrostatics, and evolution, in a similar way, makes speciation possible. Isolated groups of organic individuals always become different. The vital equilibrium of specific bodies of organisms is sustained by interbreeding and evolutionary motion. Analogies of physical phenomena of rest and inertia do not apply. To hold organic types uniform and stationary by selection has been attempted many times, but degeneration promptly ensues. Diversity and change are not the results of special evolutionary causes acting at rare intervals of species-formation, but are the normal and necessary conditions of organic existence.

To understand species-formation, evolution must be taken for granted, as an Irishman might say, and as many savants of other nationalities have unconsciously written. If we are interested merely in the positional relations of the automobile, it is enough to know that the handle can be turned and that the wheels go round. Our progress can then be nicely explained by a few properly selected factors, such as: (1) Wheel-turning (continued, inherited 'variation'); (2) roads to travel (by selection); (3) handle-turning (accommodation), to steer around corners and mud-holes. But to ask how the machine was constructed, how the handle turns it, and how the wheels happen to revolve, are bothersome questions of details with which taxonomic observers of automobiles do not need to concern themselves. Species travel because they are built that way, not because the environment pushes them.[3] Each species is equipped on the inside with the factors of its own evolution, such as heterism, symbasis and mitapsis, for maintaining the normal individual diversity and the broad network of descent which are requisite for sustained organic efficiency and evolutionary progress.[4] But all this is another story. The factors of species-formation afford very interesting matters of discussion, but let us not confuse ourselves further by imagining that they are factors of evolution.

O. F. COOK.

WASHINGTON, D. C.,
January 27, 1906.

[3] Darwin and some of his followers appear to have tacitly assumed what might be termed a specific constant of variability, so that natural selection by shearing off one side of the species could compel the other side to grow out, and thus roll the species along. How isolation could serve as an evolutionary factor seems not to have been indicated.

[4] 'Evolution of Cellular Structures,' Bull. 81, Bureau of Plant Industry, U. S. Department of Agriculture.

SPECIAL ARTICLES.

THE POSSIBILITY OF PSYCHICAL FACTORS IN ILLUSIONS OF REVERSED MOTION.

ONE of the most interesting chapters in psychological optics is concerned with what have been variously termed 'after-images of motion,' 'antirheoscopic phenomena,' 'subjective complementary movements,' or 'illusions of reversed motion,' These illusions are quite easily observed, *e. g.*, by fixating a rotating disc on which a heavy spiral line has been traced, or a rotating drum on which lines have been drawn at right angles to the direction of movement, or by watching the landscape from the window of a moving train or the waves of a stream from its bank. A very pretty demonstration (the 'water-fall illusion,' first described by Addam in 1834) may be secured by fixating for a half-minute some convenient mark seen through the falling spray of a water-fall, and then transferring the gaze to a neighboring cliff, which will promptly 'flow' upward in a most striking manner. Indeed, some observers experience all the unpleasantness of a vertigo from this simple experiment, and several writers relate the two phenomena by giving similar theoretical explanations.

These illusions of reversed motion have been under observation from time to time since the first published account by Purkinje in 1825, and have been experimentally examined in numerous ingenious ways, first by Plateau in

1849, and subsequently, to cite the best-known researches, by Oppel (1856), Helmholtz (1866), Dvorak (1870), J. J. Hoppe (1879), Thompson (1879), Zehfuss (1880), Bowditch and Hall (1880–2), Budde (1884), Exner (1887, 1888–9, 1899), Heuse (1888), Stern (1894), J. Hoppe (1894), Borschke and Hescheles (1902) and Szili (1905).

The theoretical explanations of these phenomena may be roughly divided into those based upon psychical processes and those based upon physiological processes set up in the visual apparatus. Zöllner explained the phenomena that had been described by Plateau and Oppel, as he did his own well-known illusion, as a purely psychical falsification of judgment. Budde, somewhat similarly, attributed them to false interpretation of correctly reported sense-impressions. The physiological explanations, to follow Szili, may be subdivided into three groups, according as the essential basis of the illusion is found (*a*) in eye-movement, (*b*) in the 'tailing-off' of the retinal excitation or (*c*) in specific retinal after-images of movement. The first position is represented by Purkinje and, more notably, by Helmholtz; the second by Johannes Müller, W. Stern and Wundt; the third, with various modifications, by Plateau, Dvorak, Mach, Zehfuss, J. Hoppe, Exner and Szili.

With the general conclusions of the last-named group of investigators I do not wish to quarrel, but I have noted indications that, under certain conditions, there may be an illusion of movement of apparently 'central,' if not strictly psychical, origin. As my observations were but incidental to other work, and as I have had no opportunity to make extended experiments, I can but report them, with apologies for their incompleteness, in the hope that some one may be interested to pursue the matter further.

While experimenting in the Cornell Educational Laboratory upon the transference of habits, Mr. Althaus, one of our graduate students, had occasion to teach the telegraph alphabet to several observers. To insure uniformity in 'sending' the dots and dashes, suitable perforations were made in a sheet of kymograph paper, which was then placed upon the revolving drum: contact between the metal drum and a flexible copper brush operated the sounder at each perforation. These and other conditions obliged the experimenter to watch the passage of the perforations past the tip of the brush for one to two hours daily during a period of two months—perhaps forty-five hours in all.

My experimenter was, at first, ignorant of the illusion of reversed motion, as appeared rather amusingly by the fact that for two weeks he had regularly thrown the brush out of contact whenever he stopped the kymograph, under the impression that there was an objective backward movement of the drum that might damage the contact point or the paper. Now, shortly after this, he reported that the drum appeared to reverse slightly whenever he glanced at it, without its having been seen just previously in motion—as, for instance, when first entering the laboratory for the afternoon's work. This new illusion became stronger as the experimentation went on, and finally became so persistent that, after six weeks' disuse of the kymograph, it was still strong, and, after eight weeks, still definitely present.

To test this observation, I placed on the drum a sheet ruled with vertical black stripes 4 mm. wide and 15 mm. apart. Close to the drum was placed a fixation-point, for which I found most satisfactory a bit of black cardboard 9 mm. square, provided with a small white center 3 mm. square and supported on a slender wire. When the drum (rotating about its vertical axis) was driven at moderate speed—say four revolutions per minute—the usual phenomena of illusory reversal were observable. Furthermore, by nearly continuous observation for forty-five minutes, I was able to secure a slight, but definite, reversed motion just at the moment of glancing at the drum, though after an interval of from ten to fifteen minutes of non-stimulation. But I was not able, in the time at my command, to establish the illusion so that it would persist several hours or days, as was Mr. Althaus with his prolonged tests. Recently, Professor Seashore has reported to me a somewhat similar indication of 'central' factors in an illusion

of reversed motion secured during a lengthy train journey.

If one admits the accuracy of these observations, they seem to me somewhat to modify the current theoretical explanations of the illusions of reversed motion. Such an assertion as that of Bowditch and Hall, for instance, that 'it is impossible to conceive how this persistent after-impression of motion can be a product of experience or association,' may, perhaps, be satisfactory so far as their observations go, but does not seem satisfactory when our observations after prolonged stimulation are also considered. Still, it may well be, and I think is, true that the illusion we are describing is independent of the illusion of reversed motion generally secured. On the other hand, an observation of Exner's, to the effect that an after-image of movement can be engendered by passing the eye over resting objects as well as by the usual method of moving objects past the resting eye, may possibly furnish the cue to the explanation of the matter under discussion, without the assumption of an illusion of judgment or of any other 'central' process. It may be that continued and intent scrutiny of the perforated drum-paper induced a habit of eye-movement in my experimenter, and that the sight of the drum was thereafter a stimulus which innervated unconscious eye-movements, even after the lapse of considerable time-intervals. This hypothesis, however, would appear to necessitate the acceptance of the rather debatable theory of unconscious eye-movement propounded by Helmholtz.

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A NOTE ON MID-CRETACEOUS GEOGRAPHY.

IN his Berne address, published in the October number of the *American Geologist*, Professor Osborn refers[1] to the apparent geographical unity between North and South America during the mid-Cretaceous and continuing possibly to the basal Tertiary. This connection is indicated by the fauna of the Notostylops beds of Patagonia.[2] Hauthal, who has done more or less stratigraphical work in the region referred to, published a brief note on some of these formations several years ago,[3] which is of some interest in this connection because the same observer discovered a plant-bearing layer at one horizon, which yielded a number of forms of great interest, particularly from the view-point of the phytogeographer. These plants were worked up by Kurtz.[4] His paper, from the fact that it was not illustrated and because of its place of publication and language, being in Spanish, is not likely to attract the attention of paleontologists which it deserves, and is worth recalling at this time.[5]

The plants occur at Cerro Guido in the province of Santa Cruz, in a layer of fine gray sandstone which grades upward into a coarse greenish sandstone, the whole fifty to sixty meters in thickness and overlain by beds containing Tertiary fossils.

The Argentine geologists correlate the lower Notostylops beds containing a rich vertebrate fauna and this plant horizon with the Cenomanian. If the determinations are correct, which fact it is difficult to properly estimate, because they are not figured, the plants furnish striking confirmation of this view. There are thirty-one forms described, including a new species in *Abietites, Araucarites* and *Perseophyllum*. Eliminating these from our calculations, we have twenty-eight forms, of which twenty-one, or seventy-five per cent., are characteristic types of the Dakota group flora. It is a significant fact that the meager

[1] Osborn, H. F., *Amer. Geol.*, **36**: 213, 1905.

[2] Ameghino, F., 'Sinóptico de las formaciones sedimentarias, terciarias y cretáceas de la Argentina. Anal. Museo Nacional Buenos Aires' (iii.), **8**: 1–12, 1902.

[3] Hauthal, R., 'Ueber patagonisches Tertiar, etc.,' *Zeitsch. Deutsch. geol. Gesell.*, **50**: 436–440, 1898.

[4] Kurtz, F., 'Contribuciones à la palæophytologia Argentina-Sobre la existencia de una Dakota Flora en la Patagonia austro-occidental,' *Revista Museo La Plata*, **10**: 43–60 (1899), 1902.

[5] Wilckens, *Neues Jahrb. f. Min. Geol. u. Paläont.*, **21**: 98–195, October, 1905, gives a quite full historical review and admirably summarizes our present knowledge of Patagonian geology.